APPENDIX C

UNCERTAINTIES IN MODELING CLIMATE CHANGE

Scientists studying climate change generally agree that there are still uncertainties in general circulation model (GCM) results. These are due to:

1. High Resolution Required for Accurate Findings. Running a higher resolution global model that includes several layers of the atmosphere and ocean, as well as the complex fluxes at the air-sea interface exceeds current computational capabilities. As computer power increases, efforts are being made to improve the resolution of GCMs.

2. Assumptions and Approximations. Certain physical processes affecting global climate are extremely complex, and cannot be explicitly calculated within a GCM either due to limitations on computational resources or lack of complete understanding of the physics behind the process. Nevertheless, the effects of these processes must be accounted for within the model. This is accomplished by making simplified assumptions and approximations about certain processes so that they can be easily included in the model. The model output can be very sensitive to which assumptions and approximations are made, with small changes in the approximations having a potentially large impact on model results.

A good example of this problem occurs in cloud formation analysis. The explicit calculation of the formation, growth, and dissipation of clouds within the model requires a spatial resolution on the order of a kilometer or less and a temporal resolution of minutes. Both are impractical in a GCM which normally has a spatial resolution measured in degrees of longitude and latitude, and a temporal resolution on the order of hours. Thus, the effects of clouds must be parameterized through numerous simplifying assumptions, each of which is likely to add some error to the model output.

The approximation of cloud formation and dissipation is a major source of uncertainty in climate models. Clouds increase the reflectivity of the earth’s surface, and thus provide a cooling effect. They also decrease radiation cooling, producing a warming effect. Cloud height and thickness determine which effect will predominate. Parameterization of this one factor could make a significant difference in modeled results.

Another example is an incomplete understanding of how polar ice-sheets will be affected, which in turn will affect sea level changes. This also impacts albedo[1], as ice and snow are strongly reflective and water and soil absorb heat, resulting in dramatic changes in the distribution of heating and accelerated warming of the poles.

3. Regional Effects and Distribution of Climate Change. While there is agreement that the global climate will continue to change, exactly where and how are not known. At this time, models cannot predict which continents will suffer or benefit from climate change.

[1] Albedo refers to the fraction of light or electromagnetic radiation that is reflected by a surface or body.